System-Level Validation through Post-Flight Reconstruction and Anchoring

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Report Documentation Page

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Purpose

Describe the approach of using System-Level Post-Flight Reconstruction (SPFR) as a Model and Simulation (M&S) Validation method for the Missile Defense Agency

MDA VV&A Definitions

Three interrelated but distinct processes that gather and evaluate evidence to determine, based on the simulation's intended use, the simulation's capabilities, limitations, and performance relative to the real-world objects it simulates are:

- **Verification:**
  - Process of determining that a model implementation and its associated data accurately represent the developer's conceptual description and specifications
- **Validation:**
  - Process of determining the degree to which a model and its associated data are an accurate representation of the real-world from the perspective of the intended uses of the model
  - Techniques are not limited to comparison of simulation results with test data. Among the other techniques employed are data validation, sensitivity analyses to evaluate input/output relationships, comparison with other models and simulations known (or assumed) to have validity in the operating range required (benchmarking), and the results of SME reviews of M&S outputs (face validation)
  - One method of validation is anchoring
- **Accreditation:**
  - The official certification that a model, simulation, or federation of models and simulations and its associated data are acceptable for use for a specific purpose

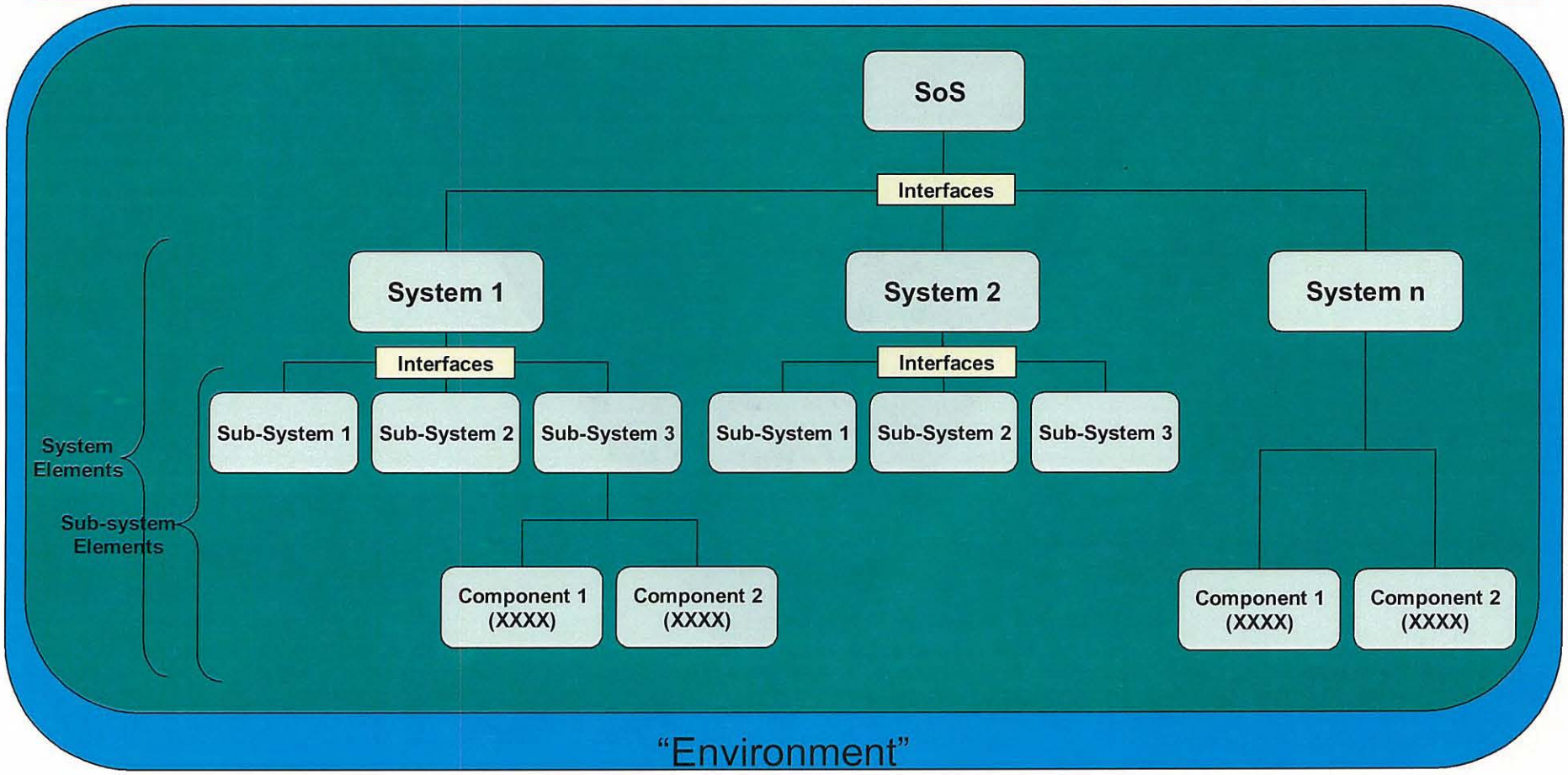
Source: MDA Directive 8315.aa, June 2007 – M&S Recommended Practices Guide (RPG)

System-Level Post-Flight Reconstruction and Anchoring Definitions

- **System-Level Post-Flight Reconstruction (PFR):**
  - » Manually recreate and run a past flight test scenario in a test venue performing system-level comparative analysis of the real-world performance to the output of the test venue assessing the results and determining if system-level anomalies exist in the Models & Simulations (M&S)

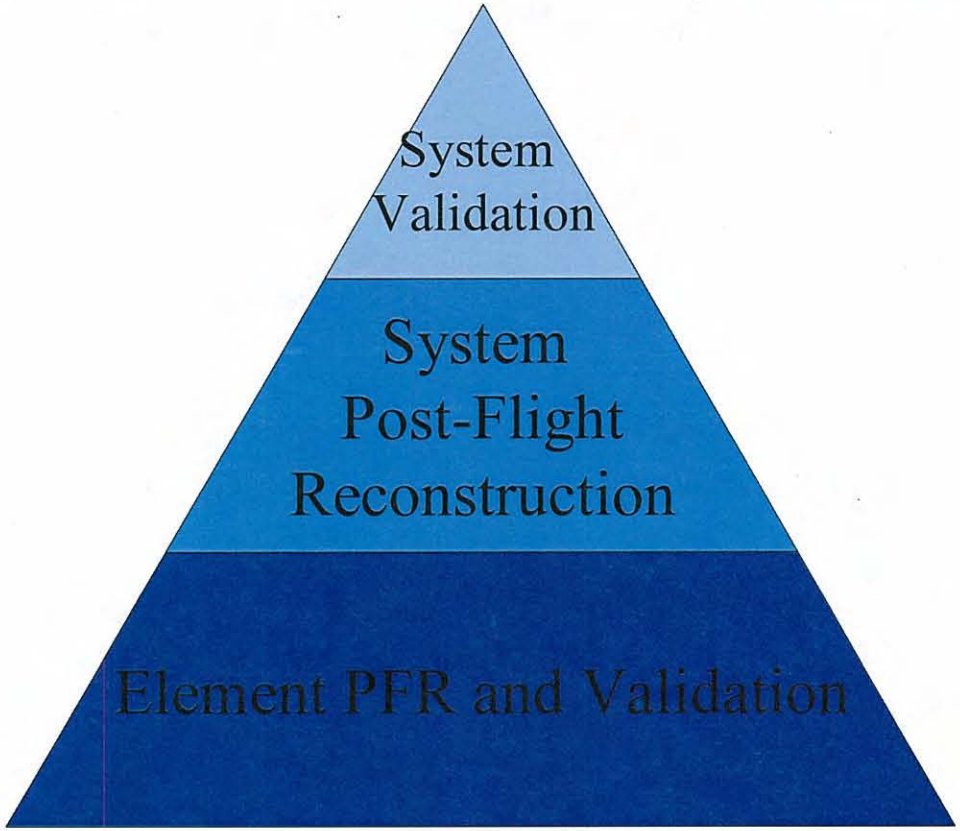
- **System-Level Anchoring (SLA):**
  - » Perform root cause analysis of the system-level anomalies found in the PFR; generate, test and implement M&S improvements to address anomalies

System of Systems



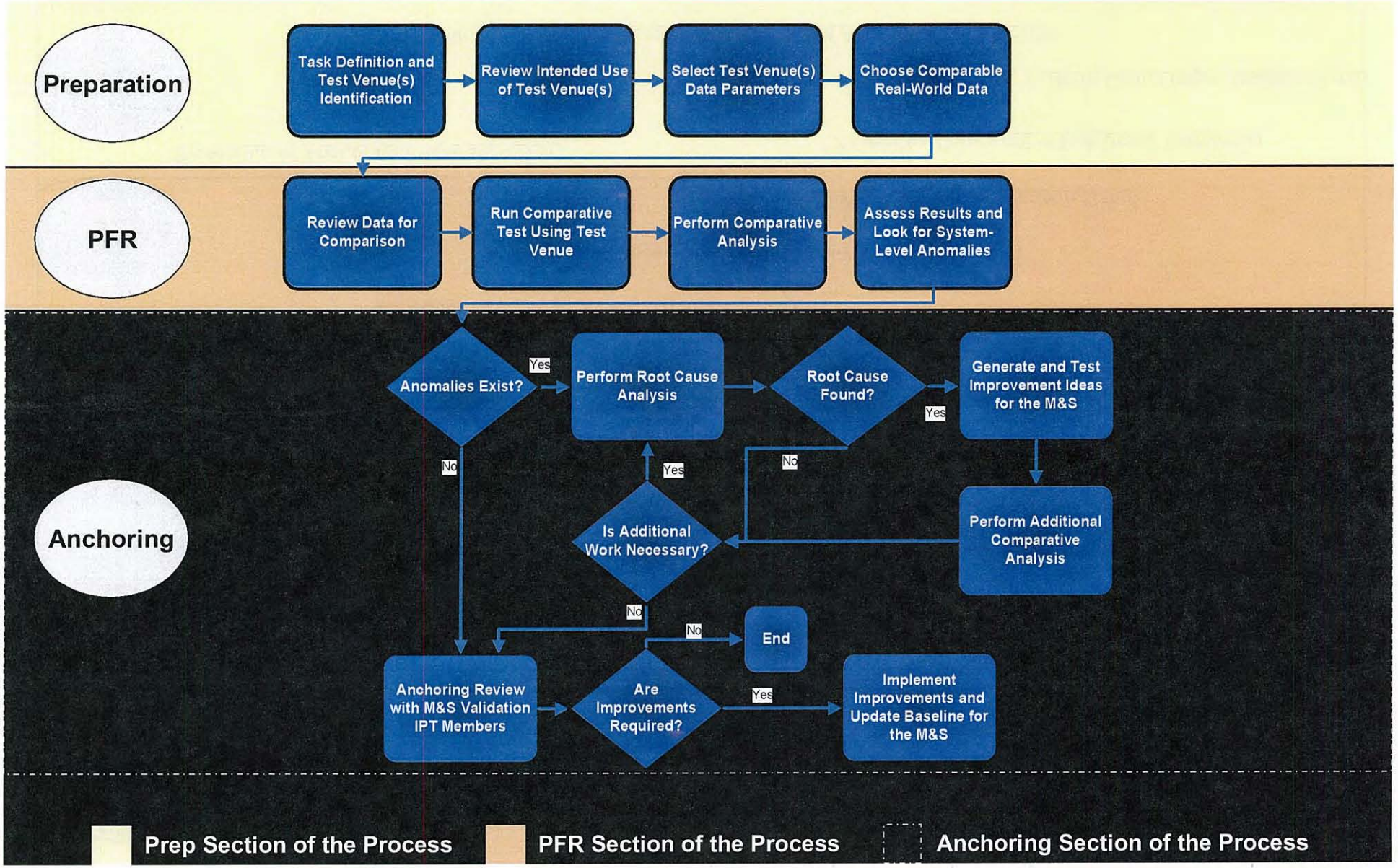
Independent systems integrated into the larger System of systems

Foundation of System PFR

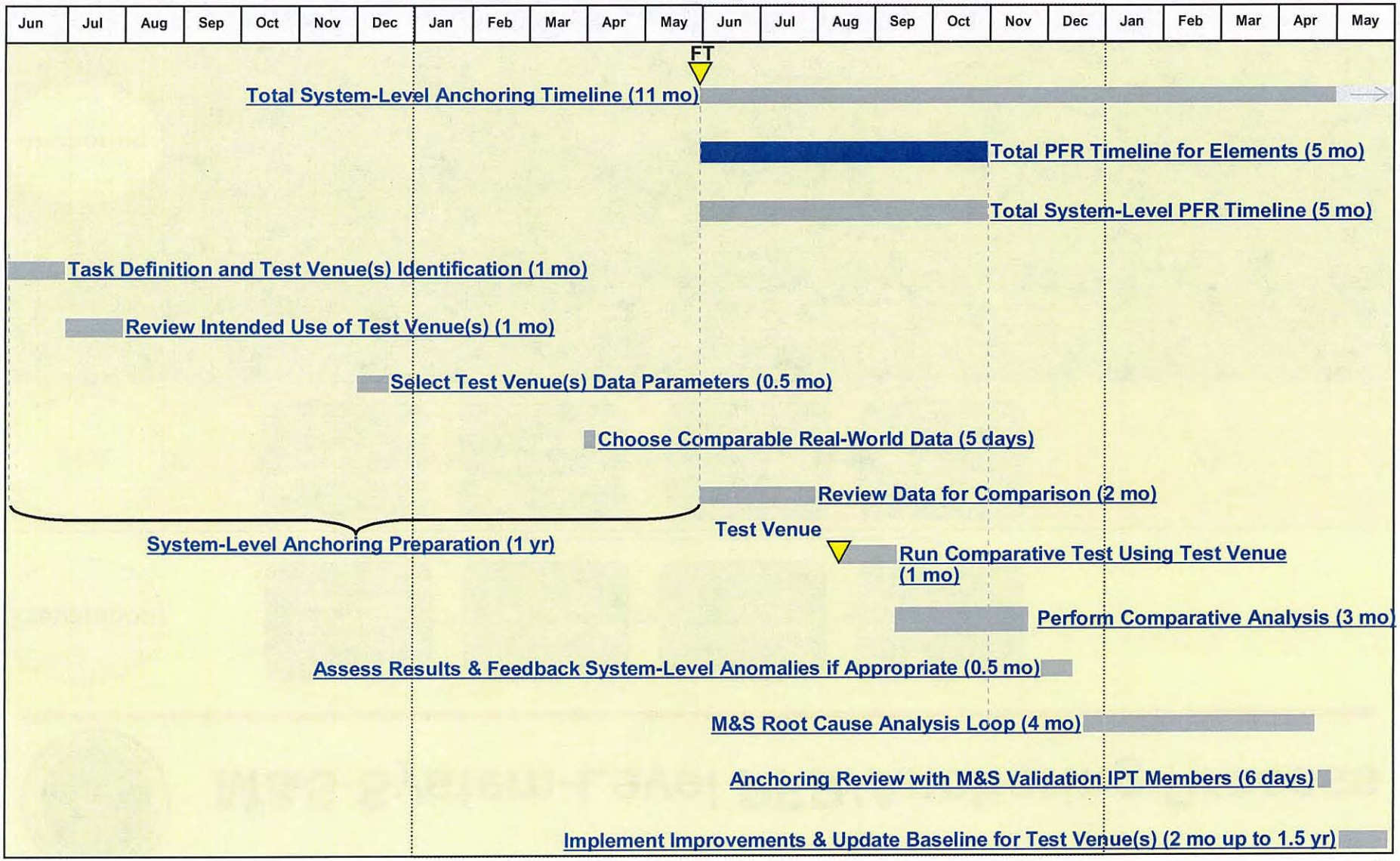


System-Level Validation is built on individual Element Validation

M&S System-Level PFR/Anchoring Process



System-Level PFR and Anchoring Process Notional Timeline



Factors Influencing the M&S System-Level PFR and SLA Process

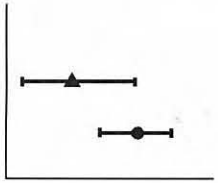
- Executive-level management requirements (i.e. timeframe, perform PFR only or follow the process through to M&S improvement (Anchoring), etc.)
- Number of parameters to be validated
- PFR lab location and schedule
- Element funding and allocation
- Integrated or distributed lab configuration
- Hardware-in-the-loop (HWIL) and/or end-to-end digital simulation
- Required organizations and resources
- Intended uses
- Who will generate the threat input
- Which signature package will be used
- S/W configuration change cycle
- S/W configuration comparisons

System-Level Analysis (SLA)

- Verification
  - Was the Test able to show Objectives were met or not met?
- Validation
  - How close do the models match real-world?
- Threat / Target
  - Does radar model response reflect real-world play backs?
  - Was Threat presented to Elements consistently?
    - Trajectory (Pos, Vel, Acc, Body Axis, Body rates) comparisons
    - Signature comparisons
- Environment
  - Is the modeled Environment representative of real-world?
    - Modeled weather comparisons to real world observations
    - Degradations of Element performance due to weather conditions
- Interfaces between different Elements (not within a single Element)
  - Is the modeled architecture appropriate for the test?
  - Does the message flow / interaction between Elements match the real-world test?
    - Number of Messages in/out, Types of Messages, Message Content, Latency
- System-Level Key Functions and Data Elements
  - Once defined need to be applied to PFR analysis
- Kill Chain Functions applicable to Entire System
  - Detect, Track, Discriminate, Engage, Negate, Assess
    - Did the model perform these functions like the real-world system?

Anchoring Methodologies Considered

Case #1: Point-to-Point Comparison Using GT

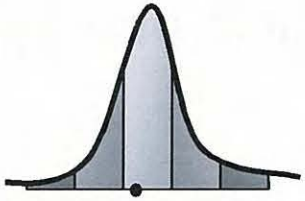


Legend
- ● Real World
- ▲ Ground Test

Pros:
- Quick look at data
- More timely analysis
- Analysis tool is not required

Cons:
- Sample data set is not statistical and may not represent the full sample space
- Lower confidence in the assessment or assessment may not be possible
- Tolerance may not be accurate

Case #2: Statistical Comparison Using Digital Representation

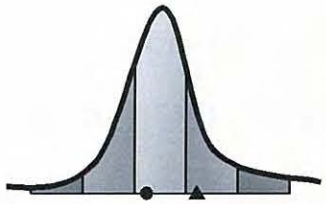


Legend
- ● Real World
- Digital Representation

Pros:
- Sample data set is statistical
- Higher confidence in the assessment
- More accurate root cause analysis

Cons:
- Not all models can emulate a FT exactly
- Analysis tool is required
- More time consuming to analyze data

Case #3: Combination of Case 1 and 2



Legend
- ● Real World
- Digital Representation
- ▲ Ground Test

Pros:
- Sample data set is statistical
- Highest confidence in the assessment
- Faster root cause analysis
- More thorough analysis

Cons:
- Not all models can emulate a FT exactly
- Analysis tool is required
- More time consuming to analyze data

Path Forward

- **Case #3**
  - Prove & develop the process utilizing available HWIL test data and a known Digital Representation

- **Where we are:**
  - Develop and prove the process in 2008 prior to the 2009 campaign

- **Where we are going:**
  - Planning 2 HWIL and 1 End-to-end digital simulation SPFR/SLA efforts in 2009
  - Using 2008 lessons learned to refine process